APPLICATION OF GEOSTATISTICS TO PREDICT LAND USE PATTERN OF URBAN AREA: A CASE STUDY ON BOGRA CITY

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Abstract: The study has been undertaken to investigate the land use and land cover change of Bogra City (Bogra Pourashava) and to show a land use scenario of the same city for 2025. In this study, three different indices havebeen used named, NDVI, MNDWI and NDBI. The value range of all the indices is -1 to +1. Using theses indices, we have separated different types of land use of Bogra city (Bogra Pourashava). NDVI helps to indentify Vegetation or Forest coverage. MNDWI has been applied to find out water body and NDBI extracts built-up area. However, Land use and land cover of Bogra City (Bogra Pourashava) is changing day by day. Vegetation, Water body and bare soil area replacing by built-up area. Due to human intervention, built-up will be the highest category of land use in Bogra City (Bogra Pourashava) as it is going to cover more than 80% of the total area by 2025.

IndexTerms– Landsat, NDVI, MNDWI, NDBI, LULCC

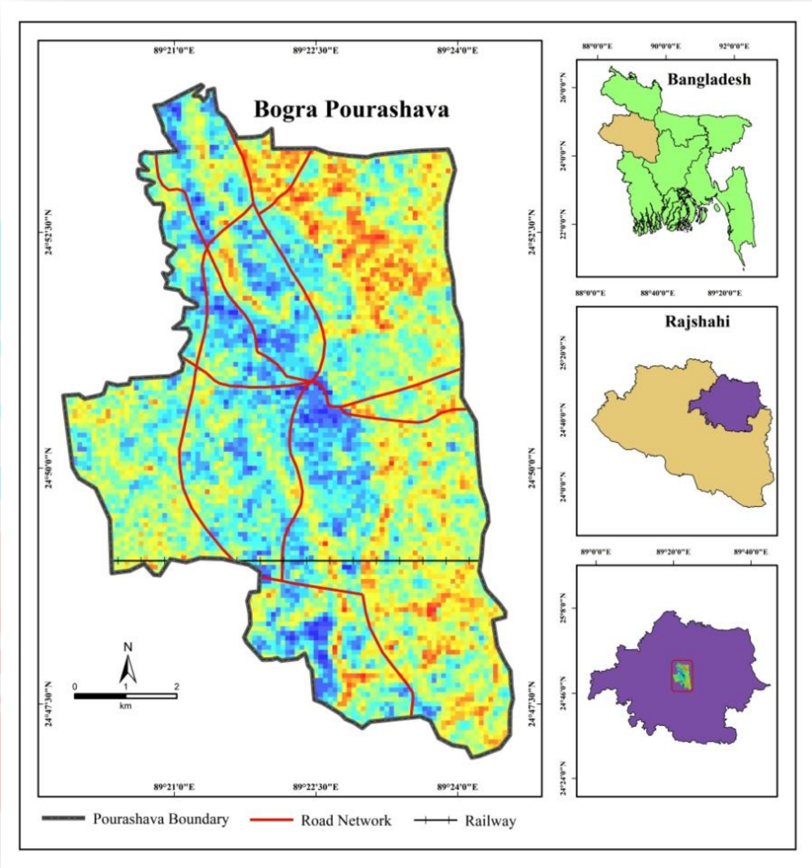
I. Introduction: Land use/land cover changes are critical issue that degrade biodiversity and create impact on human life. The International Geosphere-Biosphere Program (IGBP) and the International Human Dimension Program (IHDP) initiated a joint international program to study the land use/land cover change (LULCC) considering the enormous impacts and implications generating from the changes of land use/land cover. They commended the necessity of improved understanding, modeling and projections of land dynamics from global to regional scale and focusing particularly on the spatial explicitness of processes and outcomes [Geoghegan *et al.* 2001].

Land use change (LUC) is the modification of a piece of land. This change is based on the purposes of need, which is not necessarily only making the change in land cover but also change in intensity and management [Verburg *et al.* 2000]. Land use change can cause a change in land cover and an associated change in carbon stocks (Bolin & Sukumar 2000). Some studies have reviewed the effects of certain land use changes on soil carbon stocks, such as forest clearing (Allen 1985**)**, tropical forest clearing (Detwiler 1986), disturbance and recovery (Schlesinger 1986), cultivation (Mann1986; Davidson & Ackerman 1993), deforestation for pasture (Neil &Davidson 2000), and from cultivation and native vegetation into grasslands (Conant et. al. 2001). The objective of this paper is to review the changes of various land use like, water bodies, vegetations, Built-uparea, bare soil and to summarize the data from the literature using Meta analysis. Land cover iscommonly defined as the vegetation (natural or planted) or man-made constructions (buildings, etc.) which occurs on the earth surface. Water, ice, bare rock, sand and similar surfaces also count as land cover. Land use and land cover have some fundamental differences. Land usemeans recreation, wildlife habitat or agriculture; it does not describe the surface cover on the ground. In short, land use indicates how people are using the land, whereas land cover indicates the physical land type. Both types of data are most often obtained from analysis of either satellite or aerial images.Understanding both the land use and land cover of a track of land provides a comprehensive picture of a particular area. This data is a fundamental component of the planning and decision-making processes for many communities because it helps them to understand better where to plan for different types of growth and where to preserve; it also helps to understand the connectivity or fragmentation of various features in their community.

However, to see the present condition and to predict the future scenario of Bogra city (Bogra Pourashava) the usefulness of geospatial technology cannot be overstated. Nowadays, RS and GIS techniques are being widely used to assess natural resources and monitor environmental changes. It is possible to analyze land use/land cover change dynamics using time series of remotely sensed data and linking it with socio-economic or biophysical data using GIS. The incorporation of GIS and RS can help analyzing this kind of research in variety of ways like land cover mapping, detecting and monitoring land cover change over time, identifying land use attributes and land cover change hot spots etc. [Lambin, 2001].

Applications of geospatial technology enable us to explore the existing land use condition of a particular area. The availability of remote sensing data greatly helped mapping and managing earth resources, but its contribution in assessment of temporal changes has been widely used and proved beneficial [Waqar et al. 2012].

II. Study Area: Bangladesh has many grown-up cities and towns**.** Bogra is the major city of Bogra district, Rajshahi division and it is theoldest city of Bengal (Bongo) previously called Pundrabardhan. The city first formed in 1821, the administrative district of Bogra contains an area of 1,359 sq. mile (3520 km^2). The major rivers of the district are formed by the different channels of the Brahmaputra; some local names of these channels are Konai, the Daokoba andeastern boundary of the district formed by JamunaRiver. The Brahmaputra and its channels, together with three minor streams, the Bengali, Karatoya and Atrai, allow significant facilities for the usage of commerce. In 1911, the Karatoya (which flows from north to south), divided the district into two portions, the eastern tract consisting of rich alluvial soil, subject to fertilizing inundations and yielding heavy crops of coarse rice, oil-seeds and jute, while the soil of the high-lying western portion of the district allow for growing rice (Chisholm Hugh,1911). Our research area is Bogra Pourashava in the district of Bogra. It was established in first July, 1876.It was the area of about 1.25 km^2in the past. The study area is 61.95 km^2.The absolute location of the area is89°21'to 89°21'north longitudeand24°47' to 24°52'east latitude.The city or pourashava bordered by Bogra Sadar Upazela,Noongola, Sekherkola at the north, Shahajanpur Union,Khota Para, Chupinagar at the south, Sub- gram Union, Gabtaliat theeast and AruliaUnion (Bogra Airport), Asekpur atthe west.Bogra Pourashava has administrative unit, educationalinstitution, religion institution,comfortablecommunication system,health complex,Clinic,Hospital,Industrial institutions,Hotel,Water provide management system, Wastages management, Economical institution,Poura park, Tourist attraction site for tourism.



Map 1: Study area

III. Materials and Methods:

In this study different indices have used to find out the changing pattern of land use in Bogra City (Bogra Pourashava). At first, Landsat TM images were extracted for 1990, 2000, 2010 and LandsatOLI_TIRS image was extracted for 2017 from USGS official website.

Table-1: Specification of Data

Year	Land sat	Resolution
1990	L-5 TM	30 x 30 m
2000	L-5 TM	30 x30 m
2010	L4-5 TM	30 x 30 m
2017	L8 OLI/TIRS	30 x30 m

- Water body: Permanent and Seasonal wetlands, low lands, and khal etc.
- Green Coverage: crop field, vegetation, forest (both natural and manmade)
- Built up Area: Residential, commercial, transport and communication
- Bare Soil: Exposed soil and landfills.

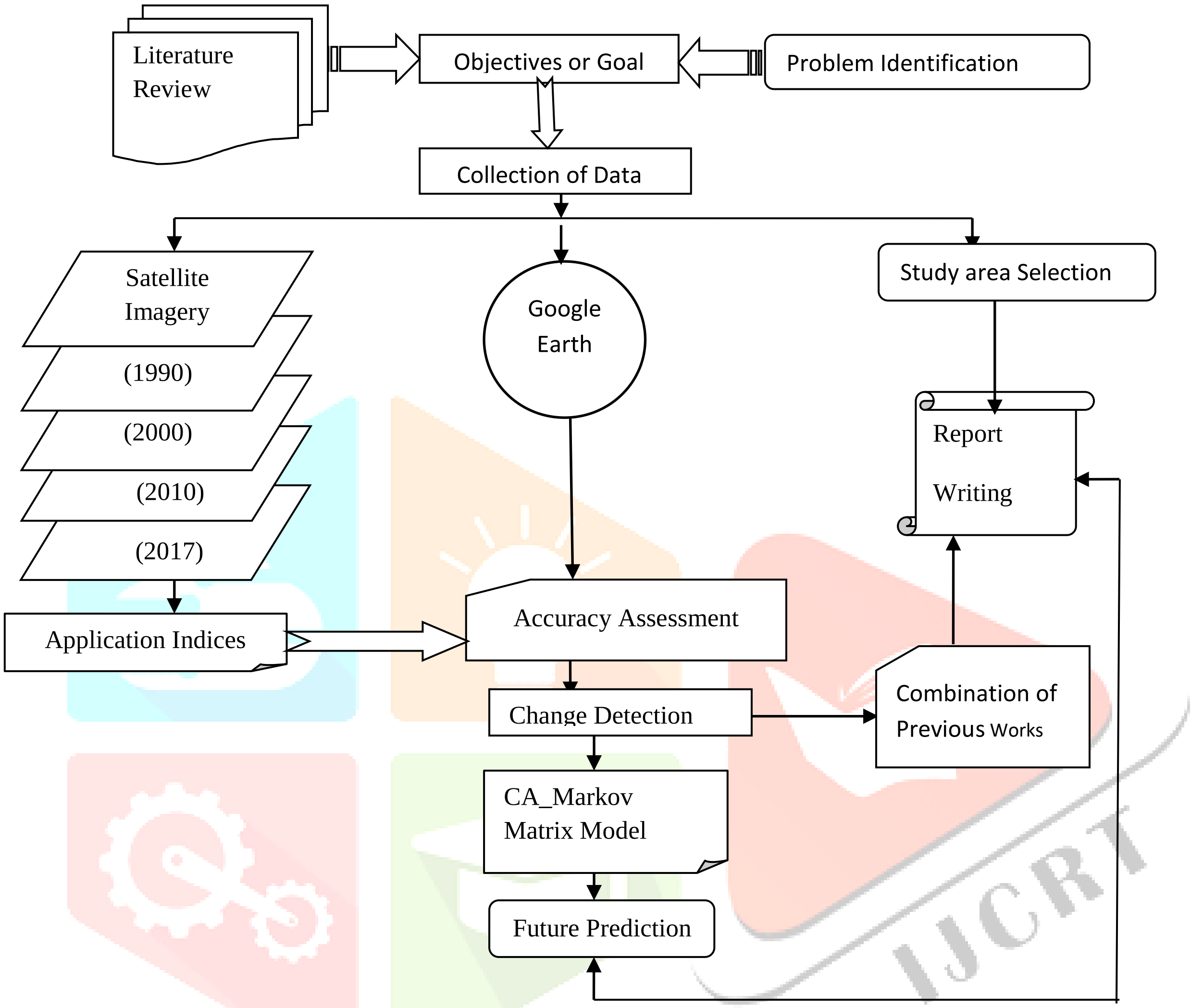


Figure 1: Showing methodology of the study

All the images were captured from January. Spatial Resolution of these images was 30 m. After extraction atmospheric corrections (Haze Reduction, Noise Reduction) and Geometric corrections were done using Polynomial Method or Polynomial Geometric Model. The RMS error of geometric correction was less than 0.3. These pre-processing operations make the images more convenient to extract a particular feature. To find out the green cover coverage, Normalized Difference Vegetation (NDVI) has been used. NDVI is the widely-used vegetation index and is basically the difference of vegetation reflectance in Near Infrared and Red bands [Rouse et al., 1974]. Typically the NDVI values from healthy vegetation will increase as plant cover increases at the beginning of the growing season, reach a peak sometime during the middle of the growing season, and will then decrease as the season comes to its end [Mkhabela et al., 2005].

After that, all those values were separated from the images which show green coverage. In the next step, separated land cover was reclassified and green cover areas were converted to vector shape.

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

Second Index that has been used in this study is MNDWI (Modification of Normalized Difference Water Index). MNDWI helps to find out surface water by suppressing errors produced by built up area. Since water features extracted using the NDWI include false positives from built-up land, a modified NDWI (MNDWI) was developed in which the middle infrared (MIR) band was replaced with the near infrared (NIR) band .The MNDWI extracts surface water while suppressing errors from built-up land as well as vegetation and soil [Xu, 2006].

$$MNDWI = \frac{Green - MIR}{Green + MIR}$$

NDBI is the third index that has been used in this study. NDBI or Normalized Difference Built Index is a new method to automate the process of mapping built-up areas [Zha et al., 2003]. Like previous two indices this index also helps us to separate built up area from the images of different years according to value.

$$NDBI = \frac{SWIR - NIR}{SWIR + NIR}$$

In the last Stage, All these output were merged then merged shape was erased from the main shape of Bogra City (Bogra Pourashava) or City to find out the bare soil.

Accuracy Assessment:
To assess the accuracy, some sample points were drawn on the classified images and these points were converted from shape to KML file to place them on Google Earth Pro and to compare the classified images with the ground. The overall accuracy of these images was 92% to 96%.

$$\textbf{Overall /Total Accuracy} = \frac{\text{Total number of correctly classified pixels (diagonal)}}{\text{total number of reference pixels}} \times 100$$

$$\textbf{Kappa Coefficient (T)} = \frac{(TS \times TCS) - \sum(Col.tot \times Row.tot)}{TS^2 - \sum(\text{col. tot} \times \text{Row. tot})} \times 100$$

Table 2: Result of Accuracy Assessment for Different Years

Year	Overall Accuracy	Kappa Coefficient (T)
1990	96%	0.92
2000	92%	0.83
2010	96%	0.92
2017	96%	0.92

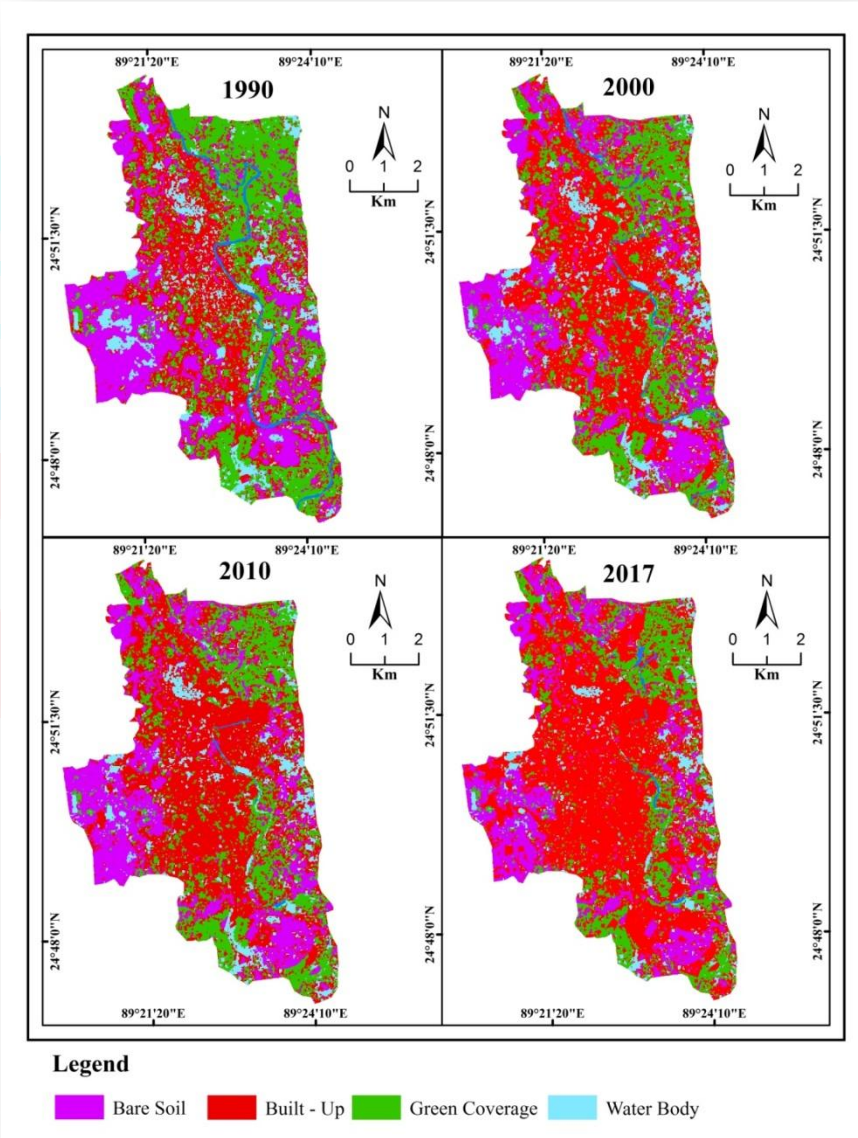
Result: In the year of 1990, area under the category water was 7.521 sq. kilometer, the same category of land use changed in the following years, in 2000, water body decreased to 4.559 sq kilometer after that, it became 3.640 sq kilometer in 2010. Moreover, the figure reached 1.570 sq kilometer in 2017. Now, if we look at the vegetation, this category of land use is experiencing a sharp change from 1990 to 2017. In the Year of 1990 area under this category of land use was 22.989 sq kilometer. By the year of 2017 the figure reached 10.044 sq. kilometer. The figure of bare soil in 1990 was 13.118 sq kilometer.

Table 3:Land Use Scenario of Bogra City from 1991 to 2017

Land Use Categories	1990	Percentage	2000	Percentage	2010	Percentage	2017	Percentage
Water	7.521	12.140	4.560	7.360	3.640	5.876	1.570	2.534
Vegetation	22.989	37.109	18.685	30.160	11.041	17.822	10.044	16.213
Bare soil	13.118	21.175	12.583	20.311	10.044	16.213	6.967	11.247
Built-up	18.323	29.576	26.124	42.169	37.226	60.089	43.369	70.006
Total	61.950	100	61.950	100	61.950	100	61.950	100

Trends: According to the trend created from the data there is a positive trend in built-up area. Except this one, all types of land use have experienced negative growth from 1990 to 2017and this trend will be continued till 2025.

In 2000, the figure decreased 12.583 sq kilometer after that, it became 10.044 sq kilometer in 2010.Howover , due to human intervention more bare soil have replaced by built-up area as a result the figure became 6.967 sq. kilometer .Built-up area is increasing day by day. People are gathering in Bogra City to manage job and new settlement the ultimate pressure of huge population are placing on different types of land uses in the year of 1990 total area under built up category was 18.323 sq. kilometer. This type of land use is grabbing more land to meet the demand of population of Bogra City. Built-up area is now the highest land grabbing category of land use in Bogra City as a result total area under built up became 70.006 sq. kilometer by the year of 2017. According to finding, in that year the percentage of built-up area is 70.006%



Map 2: Land use map of Bogra Pourashava from 1990 to 2017

However, a matrix table has produced to predict the land use pattern of 2025. Total value of every row is 1. The matrix table helps us to make a land use shifting model from 2017 to 2025 and to produce a land use prediction table for 2025.

Table 4:CA Markov Matrix Table

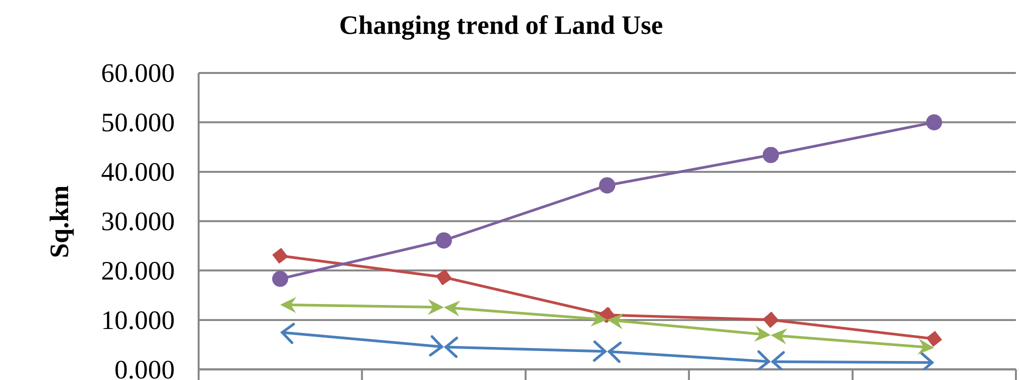
	2017					
2010	**Land Use Categories**	**Water**	**Vegetation**	**Built-up**	**Bare soil**	**Grand Total**
	Water	0.9812	0.0084	0.0052	0.0052	1
	Vegetation	0.5994	0.0614	0.3222	0.0170	1
	Built-up	0.0071	0.4092	0.4773	0.1064	1
	Bare soil	0.2050	0.4172	0.3697	0.0081	1

Tablem 5: Land Use Scenario of Bogra Cityfrom 1990 to 2025

Land Use Categories	1990	%	2000	%	2010	%	2017	%	2025	%
Water	7.521	12.140	4.560	7.360	3.640	5.876	1.570	2.534	1.393	2.249
Vegetation	22.989	37.109	18.685	30.160	11.041	17.822	10.044	16.213	6.192	9.995
Built-up	18.323	29.576	26.124	42.169	37.226	60.089	43.369	70.006	49.992	80.697
Bare soil	13.118	21.175	12.583	20.311	10.044	16.213	6.967	11.247	4.373	7.059
Total	61.950	100	61.950	100	61.950	100	61.950	100	61.950	100

As we have mentioned earlier, total area under different types of land uses are decreasing with the passing of time except built- up area. Now, if we look at 2025, more than 80% area will be covered by built- up category. This percentage is indicating that by the year of 2025 more people will gather in Bogra City (Bogra Pourashava) which will be resulted in the loss of water body, Vegetation and bare soil because these types of land uses will be replaced by built-up area to mange space for the huge crowding people of the city. The second highest land use in 2025 will be vegetation; It will cover nearly 10%. The prediction indicate that in upcoming years Bogra city (Bogra Pourashva) will face water deficiency as the percentage of water body will be 2.249% by the year of 2025 . In addition to these, more bare soil will be lost and it will cover only 7.059% of the total area by the year of 2025.

The model is demonstrating the land use shifting of Bogra City (Bogra Pourashava) from 2017 to 2025. In the year of 2025, 0.487 sq. kilometer water body will be replaced by vegetation. Total area that will be shifted from vegetation to water body was 0.603 sq. kilo meter. Now, if we look at that area which has shifted from vegetation to bare soil and bare soil to vegetation, we will see total area that shifted from vegetation to bare soil was 2.611 sq. kilometer. On the other hand, 1.254 sq kilometer area was shifted from bare soil to vegetation. This shifting pattern between bare soil and built-up area also considerable. In the years of 2025, 4.389 sq. kilometer area was shifted from bare soil to built-up area, in the same way; 0.434 sq. kilometer built-up area was replaced by bare soil. Shifting condition of land use between built-up and water cannot be neglected as 0.4354 sq. kilometer area built-up area was shifted to water body and 0.722 sq. kilometer water body was grabbed by built –up area. More closely look at the model, we will find that, the figure of shifting pattern from built-up to Vegetation and Vegetation to built- Up will be 0.434 sq. kilometer and 2.812 sq. kilometer respectively. By the year of 2025, 0.283 sq. kilometer water body will be come under the category of bare soil and 0.279 sq. kilometer bare soil will be grabbed by water body.



	1990	2000	2010	2017	2025
Water	7.521	4.560	3.640	1.570	1.394
Vegetation	22.989	18.685	11.041	10.044	6.192
Bare Soil	13.118	12.583	10.044	6.967	4.373
Built-up	18.323	26.124	37.226	43.369	49.992

Figure 3: Changing trend of Bogra Pourashava Land Use from 1990 to 2017

Here, the values that are placed in 4 circles indicating that area that will not be shifted into another category from 2017 to 2025.

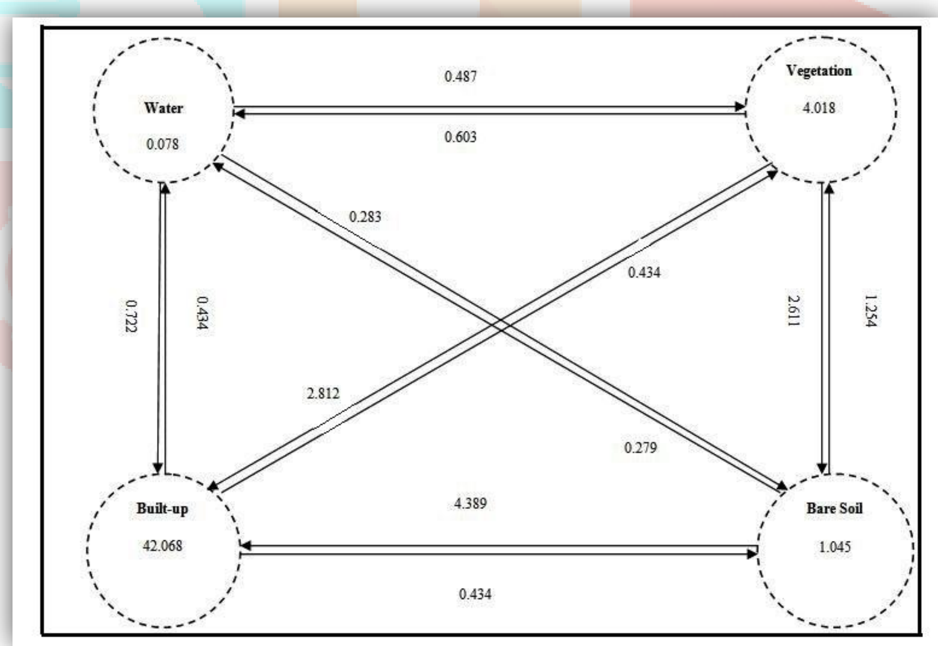


Figure-4: Land Shifting Model

Conclusion: As a growing city Bogra is going to experience huge population pressure. The ultimate result of his unprecedented population pressure is the main reason of spreading built-up area and the continuous loss of other types of land uses. From the context of urbanization it is a good sign but the sign carry some negative impacts for environmental.

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